

The mineralogy of circumstellar silicates preserved in cometary dust

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Interplanetary dust particles (IDPs) contain a record of the building blocks of the solar system including presolar grains, molecular cloud material, and materials formed in the early solar nebula [1]. Cometary IDPs have remained relatively unaltered since their accretion because of the lack of parent body thermal and aqueous alteration. We are using coordinated transmission electron microscope (TEM) and ion microprobe studies to establish the origins of the various components within cometary IDPs. Of particular interest is the nature and abundance of presolar silicates in these particles because astronomical observations suggest that crystalline and amorphous silicates are the dominant grain types produced in young main sequence stars and evolved O-rich stars [e.g. 2].

Five circumstellar grains have been identified including three amorphous silicate grains and two polycrystalline aggregates. All of these grains are between 0.2 and 0.5 μm in size. The isotopic compositions of all five presolar silicate grains fall within the range of presolar oxides and silicates [3], having large ^{17}O -enrichments and normal $^{18}\text{O}/^{16}\text{O}$ ratios (Group 1 grains from AGB and RG stars). The amorphous silicates are chemically heterogeneous and contain nanophase FeNi metal and FeS grains in a Mg-silicate matrix. Two of the amorphous silicate grains are aggregates with subgrains showing variable Mg/Si ratios in chemical maps. The polycrystalline grains show annealed textures (equilibrium grains boundaries, uniform Mg/Fe ratios, [4,5]) and consist of 50-100 nm enstatite and pyrrhotite grains with lesser forsterite. One of the polycrystalline aggregates contains a subgrain of diopside. The polycrystalline aggregates form by subsolidus annealing of amorphous precursors [4].

The bulk compositions of the five grains span a wide range in Mg/Si ratios from 0.4 to 1.2 (avg. 0.86). The average Fe/Si (0.40) and S/Si (0.21) ratios show a much narrower range of values and are ~50% of their solar abundances. The latter observation may indicate a decoupling of the silicate and sulfide components in grains that condense in stellar outflows.

The amorphous silicate grains described here were not extensively affected by irradiation, sputtering, or thermal processing and may represent relatively pristine circumstellar grains. They are strong candidates for the “dirty silicates” in astronomical observations of circumstellar dust shells. The polycrystalline grains were originally amorphous silicate grains that were likely annealed in the early solar nebula [5] but the processing was not sufficient to erase their anomalous oxygen isotopic compositions.

[1] Messenger, S. *et al.* (2006) *MESS*, 187. [2] Molster, F. and Waters, L.B.F.M. (2003) *Astromineralogy*. Ed. T.K. Henning., Lecture Notes in Physics, vol. 609, 121-170. [3] Nittler L.R. *et al.* (1997) *ApJ* 483,475. [4] Keller, L. P. and Messenger, S. (2009) *LPSC XXXX*, 2121. [5] Messenger, S. and Keller, L. P. (2010) *LPSC XXXXI*, 2483.